Consequences of Selected Macroeconomic Policy Changes on Nutrient Availability of Household Groups

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CONTENTS

1. Introduction

The policy changes at the macro level can have substantial impact on decision making and outcomes at the household level affecting a number of welfare indicators e.g. consumption of food, expenditure on health care, and participation in the labour force. Such macro policy changes usually affect various household groups through their impact on prices facing the households and their income levels. In other words, changes in output and input prices as well as changes in income levels are the primary transmission channels through which the effects of a macro economic policy change influence the household groups. Even though such impact at the household level may turn out to be an important policy indicator, empirical evidence on the nature and magnitude of these impacts are generally lacking in Bangladesh. The present paper examines the consequences of selected macroeconomic policy changes on the nutrient availability by households groups in Bangladesh.

The paper is organized as follows. The analytical framework which employs a linked model is discussed in Section II. The simulation results are presented in Section III. Finally, important policy implications and concluding observations are discussed in Section IV.

2. Framework of the Linked Model

Within the framework, the impact of macro economic policy changes on the nutritional status of eight household groups has been simulated using a linked model. The linked model works as an outcome field where the estimates of elasticity (e.g. income and price elasticities) from the elasticity model and changes in sectoral prices and household incomes derived from the computable general equilibrium (CGE) model are combined to generate the impact on nutrition status of the household groups. The nutrition status of the households are measured in terms of calorie and protein availability.

The Elastıcity Model

Within the elasticity model, Food Chracteristics Demand System (FCDS) has been used to estimate the complete demand system for different occupational groups in Bangladesh. Under the method, energy, variety, and taste of individual foods are considered as characteristics and these are assumed to be additive in the individual's utility function. In the utility function, consumption of one food depends on the level of consumption of all other foods. By specifying an explicit functional form of these characteristics in the utility function, the entire matrix of price and income elasticities can be derived for a system of n foods and one non-food commodity. A summary on the methodology is given at Annex I.[1]

Overview of the CGE Model

A multi-sector, multi-households, and multi-factor CGE has been to used to analyse the possible consequences of trade liberalisation on the economy of Bangladesh. The structure of the model is presented in Figure 1 and Figure 2. The generation of sectoral supply is shown in Figure 1, while in Figure 2 the structure of demand is presented. The model is numerically specified for the fiscal year 1992-93. The social accounting matrix (SAM) constructed for 1992-93 served as the data set for the model. The model is presented at Annex 2.[2]

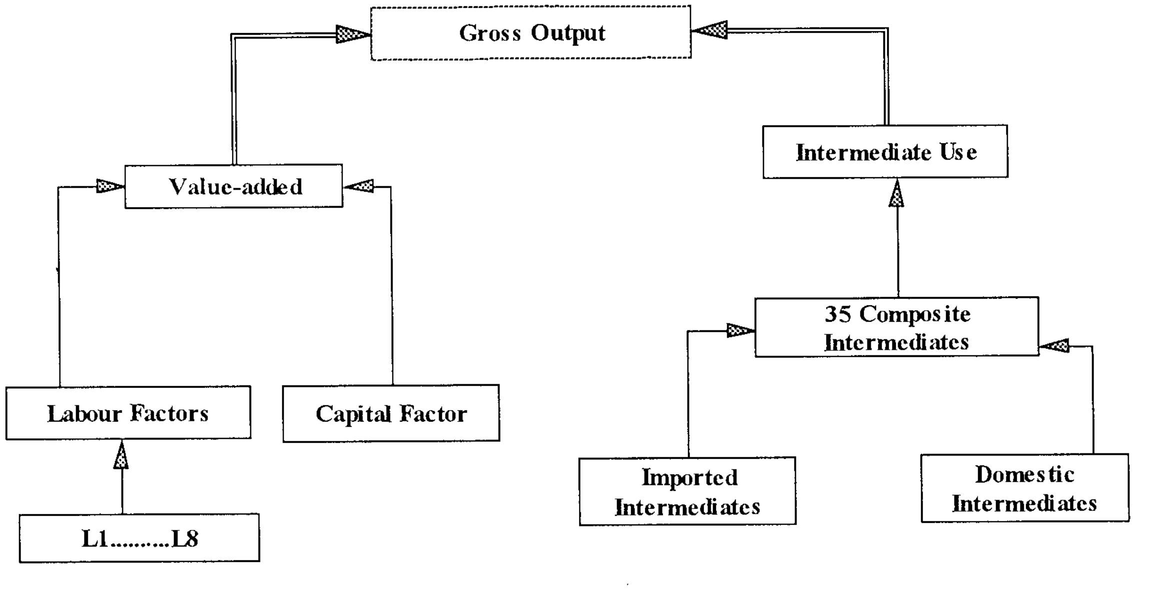
Production Structure: Intermediate Demand and Value Added

The production structure of the model is shown in Figure 1. The gross output is a Leontief function of intermediate use and value added. Each of the 35 sectors produces output using primary factors of production, according to the neoclassical production function exhibiting constant returns to scale. Each sector also uses intermediate inputs, which are assumed to be in fixed proportion to gross output.

[1] For a detailed discussion on the technique and estimation results, see CIRDAP, 1998.
[2] For details of the model structure and the underlying SAM, see CIRDAP, 1997, 1998.

For intermediate inputs, a Leontief (fixed coefficients) specification is employed. Thus there is no scope of substitution between intermediate inputs and primary inputs as specified by a fixed coefficient system. The 35 composite intermediates are a CES function of imported inputs and domestic inputs envisaging substitution possibility between domestic and foreign intermediate inputs. On the other hand, value added is modeled via a Cobb-Douglas function of eight types of labour factors and one capital factor.

Figure 1



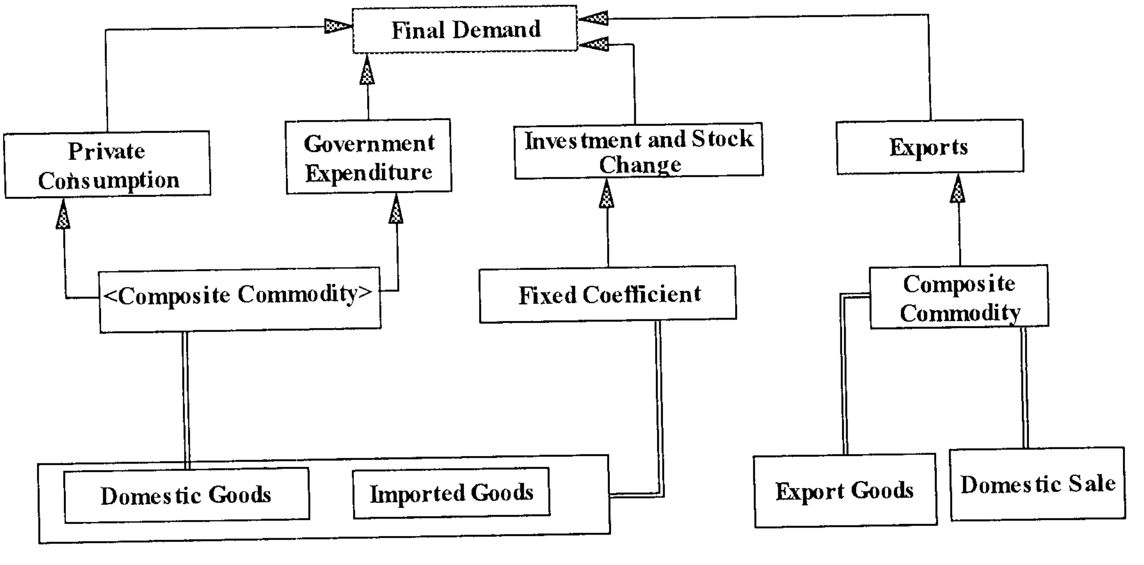
Structure of Final Demand

The final demand structure of the model is shown in Figure 2. Private consumption demand for each of the eight household groups is characterised by representative consumers from each of the groups who maximise a Cobb-Douglas utility function. Private consumption expenditures are allocated among domestic and imported goods.

Foreign and domestic consumer goods are assumed to be imperfect substitutes following Armington (1969), thereby accommodating the phenomenon that the country both imports and exports the same commodity.

The distribution of investment and stock changes is modeled using a fixed coefficient specification. The main sources of government incomes are revenue from different types of tax and non-tax sources. The government expenditures are assumed to be exogenous but expenditures excluding transfers are derived from a Cobb-Douglas utility function. The government is assumed to spend a part of tax and tariff revenues for transfer payments to household groups and to other institutions.

Figure 2



The Linked Model

The income and price elasticities (own and cross) of demand for food are estimated in the elasticity model using the household expenditure survey data and adopting the FDCS technique. Price and income changes as a result of macro economic policy changes are obtained from the CGE model. The resulting price and income changes are then combined with estimated price and income elasticities to estimate changes in demand for food. The changes in the demand for food are then translated into changes in calorie and protein consumption using vectors of calorie and protein contribution by each commodity. It is assumed that other household characteristics are unaffected by policy changes. In the situation, one can then use the average contribution of each food item to specific nutrients of interest to derive the implications of macro economic policy changes on nutrient consumption of households groups.

Formally, the demand for food can be expressed in percentage terms as follows

$$\hat{QD}_j^h = \sum_J \mathrm{E}_{ij}^h \cdot \hat{P}_j + \mathrm{T}_i \cdot \hat{Y}^h$$

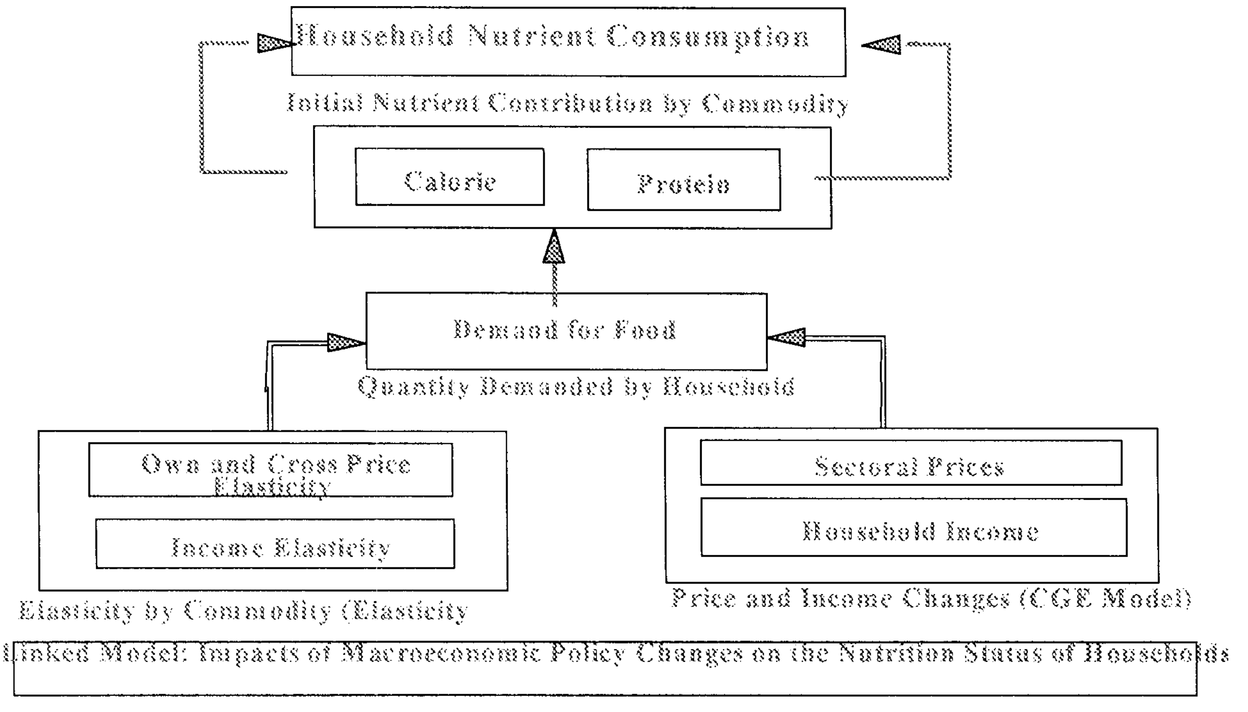
Where, QD indicates percentage change in quantity demanded. E denotes own and cross price elasticity. T refers to income elasticity by household groups. P and Y depict percentage changes in prices and income.

One can then use the average contribution of each food item to specific nutrients of interest (e.g. calorie and protein) to derive the implications of macro economic policy changes on nutrient consumption of households using the following relation:

$$\hat{NC}^h = \sum_j \mathrm{K}_j \cdot \hat{QD}_j^h$$

Where, NC refers to changes in nutrition consumption by household groups and K denotes initial nutrient contribution of commodity. An overview of the linked model is shown in figure 3.

Figure 3



3. Simulating Nutrition Effects of Price and Income Changes

A macro policy change usually affects household groups through its impacts on commodity prices and income levels of the household groups. Within the purview of the MAP project, the impact of macro economic policy changes on the nutrition status of eight household groups has been simulated using the linked model. The linked model works as an outcome field where estimates of elasticity from elasticity model and changes in sectoral prices and household income are combined to generate impacts on nutrition status of household groups.

For the purpose of the present exercise, changes in prices and income are obtained from tariff liberalisation simulations. The alternative scenarios involve the following:

TM: Reduction of nominal tariff rates as implemented during the fiscal year 1996-97. In this experiment, no adjustments are made in domestic indirect tax rates or direct tax rates to bridge the deficit generated in government revenue as a consequence of reduction of tariff rates.

TM1: Reduction of nominal tariff rates along with adjustment of manufacturing value-added tax rate to maintain neutrality of government revenue.

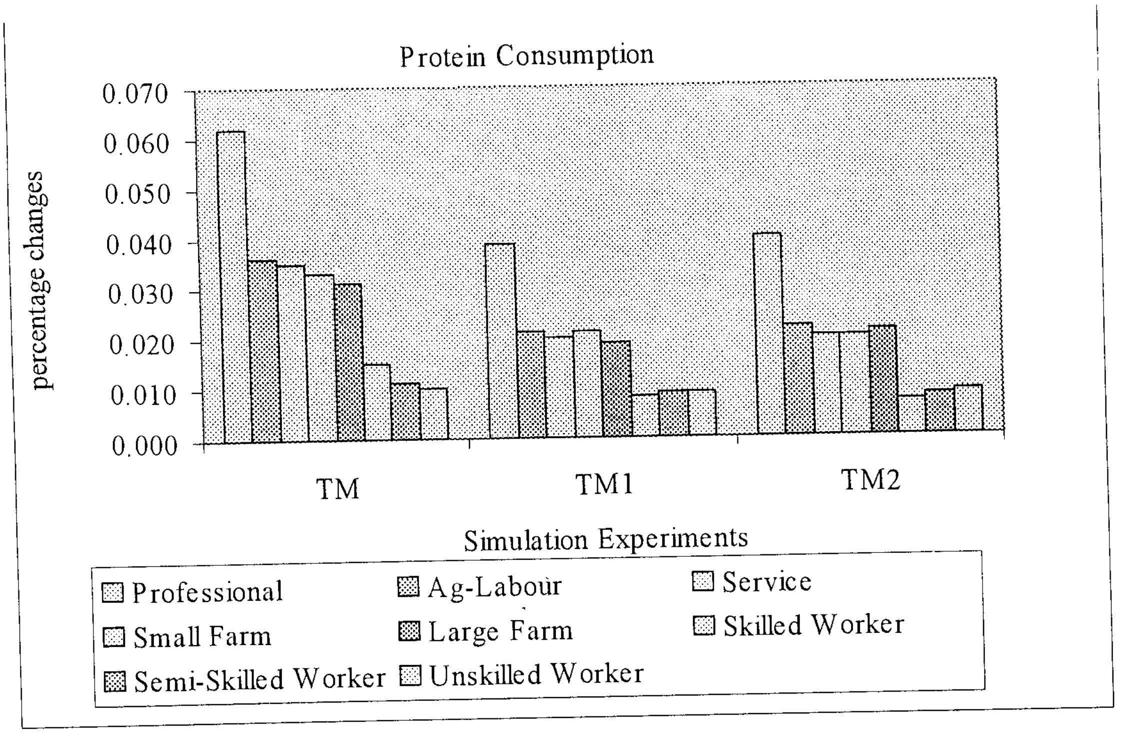
TM2: Reduction of nominal tariff rates along with introduction of lower value-added tax rate (i.e. VAT rates are lower than the standard rate applicable to manufacturing value added and imports) for construction, miscellaneous service sector and trade sector to maintain neutrality of government revenue.

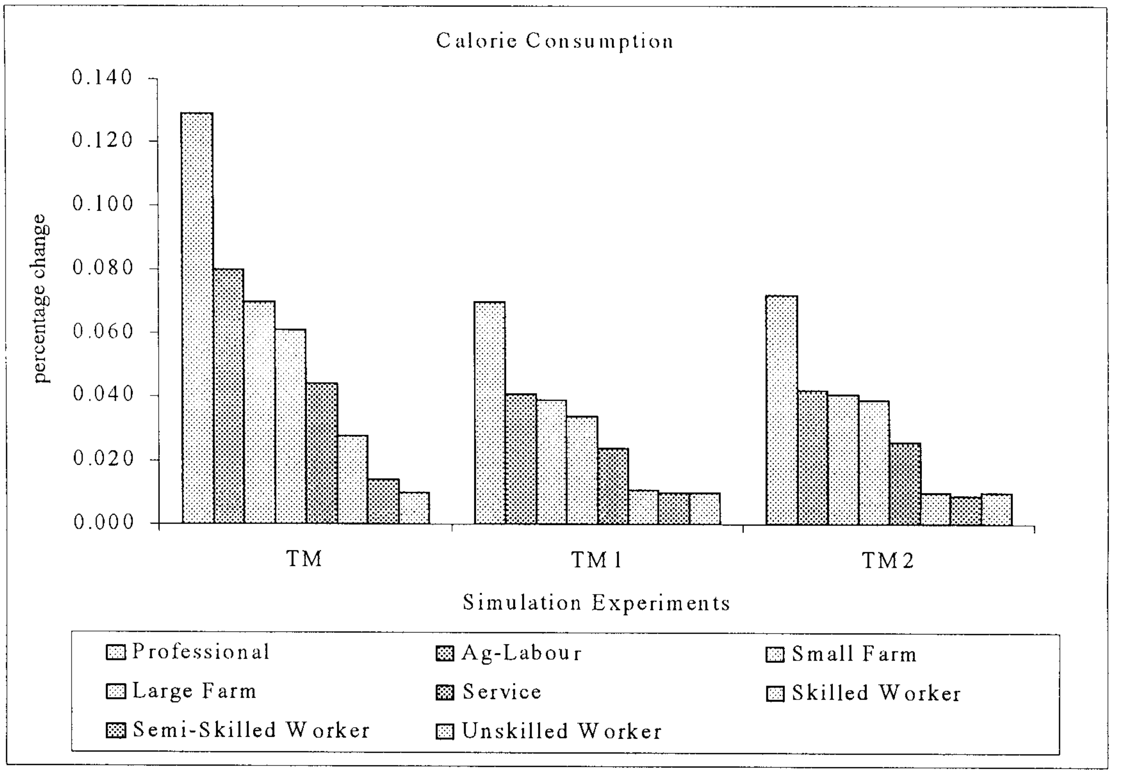
Commodity price and income changes by household groups are shown in Appendix Tables A1 and A2. These price and income changes resulting from the three tariff liberalisation experiments are used to examine the impacts on nutrient availability of household groups.

Using the demand equation, one may compute the changes in demand for food as a result of changes in prices of food items and incomes of the household groups. The changes in quantity demanded for food items are then combined with vector of nutrient contribution by food commodity to derive changes in protein and calorie availability for the household groups. The methodology is general and can be used to examine nutrition impact of other policy changes as long as changes are obtained in terms of food prices and household incomes.

The impact of tariff liberalisation experiments on the availability of protein and calorie availability to household are shown in Figure 4. In particular, Figure 4 shows the changes in protein and calorie availability by eight household groups under the above tariff liberalisation experiments. It is observed that, the tariff liberalisation experiments appear to be regressive in terms of macro nutrient availability of the household groups. That is, the percentage change in protein and calorie availability is large for high-income groups compared to the low-income groups. Except for the agricultural labour households, both calorie and protein availability are greater for the higher income household groups. Another important observation is that, nutrient availability is significantly lower for the workers households compared to other five household groups. This is largely due to lower changes in income for the worker households. Another observation is that the percentage change in protein and calorie availability is relatively larger in the first experiment compared to the other two experiments since income effects are high and price affects are low in the first experiment.

Figure 4: Changes in Protein and Calorie Consumption





4. Concluding Observations

In this paper the estimates of own and cross price elasticities of major food items are combined with price and income changes to derive implied impact on the availability of calorie and protein at the household level. In particular, the paper shows the changes in protein and calorie availability by eight household groups under tariff liberalisation experiments. It is observed that, the tariff liberalisation experiments appear to be regressive in terms of nutrient availability of the household groups. The percentage change in protein and calorie availability is large for high-income groups compared to the low-income groups. Another important observation is that, nutrient availability is significantly lower for the workers households compared to the other five household groups since changes in income are observed to be lower for the worker households. In terms of relative impact, the percentage change in protein and calorie availability is larger in the first experiment compared to the other two experiments since income effects are high and price effects are low in the first experiment.

References

Armington, P. (1969), A Theory of Demand for Products Distinguished by Place of Production, IMF Staff Paper, 16.

Boadway, R. W. and N. Bruce (1984), Welfare Economics, New York, Basil Blackwell.

CIRDAP (1994), Human Resource Development and Poverty Alleviation in Bangladesh, MAP Focus Study Series No. 2, CIRDAP, Dhaka.

CIRDAP (1994), Public Expenditure and Poverty Alleviation in Bangladesh, MAP Focus Study Series No. 1, CIRDAP, Dhaka.

CIRDAP (1996), Database for the General Equilibrium Model: Input – Output and Related Tables for the Bangladesh Economy, MAP Working Paper Series No. 2 (Revised), CIRDAP, Dhaka.

CIRDAP (1996), Report of the CIRDAP-BBS National Seminar on Poverty Monitoring, CIRDAP Study Series No. 174, CIRDAP, Dhaka.

CIRDAP (1996), Report of the Poverty Monitoring Survey 1994, Regular and Continuous Monitoring of Poverty Situation in Bangladesh, Bangladesh Bureau of Statistics (BBS), Govt. of Bangladesh, Dhaka.

CIRDAP (1996), Report of the Poverty Monitoring Survey, April 1995, Regular and Continuous Monitoring of Poverty Situation in Bangladesh, Bangladesh Bureau of Statistics (BBS), Govt. of Bangladesh, Dhaka.

CIRDAP (1996), Report of the Rural Poverty Monitoring Survey, December 1995, Regular and Continuous Monitoring of Poverty Situation in Bangladesh, Bangladesh Bureau of Statistics (BBS), Govt. of Bangladesh, Dhaka.

CIRDAP (1996), Report of the Urban Poverty Monitoring Survey, December 1995, Regular and Continuous Monitoring of Poverty Situation in Bangladesh, Bangladesh Bureau of Statistics (BBS), Govt. of Bangladesh, Dhaka.

CIRDAP (1997), A Social Accounting Matrix for Bangladesh Economy 1992/93 : A Basis for Fixed Price and Flex Price Models, MAP Technical Paper Series No.1, CIRDAP, Dhaka.

CIRDAP (1997), Poverty Profile and Poverty Alleviation Effects in Bangladesh: A SAM Based Analysis, MAP Technical Paper Series No.2, CIRDAP, Dhaka.

CIRDAP (1997), Report of the CIRDAP-BBS National Seminar on Poverty Monitoring, CIRDAP Study Series No. 175, CIRDAP, Dhaka.

CIRDAP (1998), A Computable General Equilibrium Model for Poverty Monitoring in Bangladesh, MAP Technical Paper Series No.3 (Revised), CIRDAP, Dhaka.

CIRDAP (1998), Report of the CIRDAP-BBS National Seminar on Poverty Monitoring, CIRDAP Study Series No. 180, CIRDAP, Dhaka.

Condon, T., H. Dahl, and S. Devarajan (1986), Implementing a Computable General Equilibrium Model on GAMS: The Cameroon Model, Unpublished Paper, April.

Cornia, G., Jolly, R., Stewart, F. eds., 1987, Adjustment With A Human Face, Oxford: Clarendon Press.

Cox, D. and R.G. Harris (1985), Trade Liberalisation and Industrial Organisation: Some Estimates for Canada, Journal of Political Economy, 93.

de Melo, J. (1987), Computable General Models for Trade Policy Analysis in Developing Countries: A Survey, Mimeo. Trade Policy Division, Country Economics Department The World Bank.

de Melo, J. and D. R. Holst (1990), Industrial Organization and Trade LIberalization: Evidence from Korea, Centre for Economic Policy Research (CEPR), Discussion Paper No. 399. June, 1990.

Demery, L. and Addison, T., 1987, Stabilization Policy and Income Distribution in Developing Countries, World Development 15, No. 12.

Dervis, K., J. de Melo and S. Robinson (1982), General Equilibrium Models for Development Policy, Cambridge University Press.

Devarajan, S. and D. Rodrik (1989), Trade Liberlization in Developing Countries: Do Imperfect Competition Matters ?, American Economic Review, Papers and Proceedings, May.

Devarajan,S. , J. D. Lewis, and S. Robinson (eds), 1995 Getting the Model Right: The General Equilibrium Approach to Adjustment Policy. Cambridge University Press, Cambridge.

Ferh, H., C. Rosenberg and W. Wiegard (1994), Welfare Effects of Value-Added Tax Harmonisation in Europe: A Computable General Equilibrium Analysis.

Foster, J. E., J. Greer and E. Thorbecke, (1984), A Class of Decomposable Poverty Measures, Econometrica, Volume 52, pp 761-766.

Francios, J. F., McDonald, B. and H. Nordstrom (1995), In Search of Robust Results: What Do CGE Models Really Tell Us About the Uruguay Round ?, The World Bank, 1995.

Gunasekera, H. Don B. and R. Tyres (1988), Imperfect Competition and Returns to Scale in a Newly Industrialising Economy: A General Equilibrium Analysis of Korean Trade Policy, Australian National University Working Paper, No. 4.

Harris, R. G. (1984), Applied General Equilibrium Analysis of Small Open Economies with Scale Economies and Imperfect Competition, American Economic Review, 74.

Harrison, G. W., Rutherford, T. F. and D. G. Tarr, (1995), Quantifying the Uruguay Round, The World Bank, 1995.

Hossain, M. Delwar (1997), Analytical Report on Poverty Monitoring Survey in Rural Bangladesh, October 1994 and April 1995, in Report on CIRDAP-BBS National Seminar on Poverty Monitoring, CIRDAP, Dhaka.

Kakwani, N. C., (1980), On A Class of Poverty Measures, Econometrica, Volume 48, pp 437-446.

Kakwani, N. C., (1993), Poverty and Economic Growth With Application to Cote D' Ivorie, Review of Income and Wealth, Series 39, No. 2, June.

Khondker, B. H., (1996) Foreign Competition, Industrial Concentration and Profitability in Manufacturing Sectors in Bangladesh, The Bangladesh Development Studies, Vol. XXIV, No. 1 & 2, March-June 1996.

Koutsoyiannis, A. (1979), Modern Microeconomics, London and Basingstoke, The Macmillan Press Limited.

Lewis, J. D. (1995), Financial Repression and Liberalisation in a Model with Financial Markets. In Devarajan, S., J. D. Lewis, and S. Robinson (eds), Getting the Model Right: The General Equilibrium Approach to Adjustment Policy, Cambridge, Cambridge University Press.

Malvin, J. (1986), Production and Trade with Two Factors and Three Goods, American Economic Review, 58(5).

Ravallion, M. and B. Sen, (1996), When Method Matters : Monitoring Poverty in Bangladesh, Economic Development and Cultural Change.

Richardson, J. D. (1989), Empirical Research on Trade Liberalization with Imperfect Competition: A Survey, OECD Economic Studies, 12, Spring 1989.

Roberts, M. (1988), The Structure of Production in Columbian Manufacturing Industries, Unpublished Paper.

Rodrik, D. (1988), Imperfect Competition, Scale Economies, and Trade Policy in Developing Countries, in Baldwin, R. E. (ed.) Trade policy Issues and Empirical Analysis, Chicago, Chicago University Press.

Sen, A. K. (1979), Poverty : An Ordinal Approach to Measurement, Econometrica, Volume 44 (2), March, pp. 219-231.

Shoup, C. S. (1990), Choosing Among Types of VATs, in Value Added Taxation in Developing Countries edited by Malcolm Gillis, Carl S. Shoup and Gerardo P. Sicat, A world Bank Symposium, The World Bank, Washington D. C.

Sullivan, C. K. (1965), The Tax on Value Added, Columbia University Press, New York and London.

Travis, W. (1972), Production, Trade and Protection when There are Many Commodities and Two Factors, American Economic Review, 62(11).

Tybout, J. (1989), Entry, Exit, Competition, and Productivity in the Chilean Industrial Sector, Unpublished Paper.

Table A1: Percentage Changes in Food Items

Commodity	*TM*	*TM1*	*TM2*
Rice	0.0177	0.0107	0.0174
Wheat	0.0889	0.0848	0.0887
Sugarcane	0.0274	0.0181	0.0272
Vegetables	0.0042	-0.0027	0.0039
Pulses	0.0205	0.0104	0.0203
Fruits	-0.0226	-0.0279	-0.0228
Tea	0.0146	0.0096	0.0144
Other Crops	0.0387	0.0318	0.0386
Livestock	0.0161	0.0087	0.0159
Fish	0.0134	0.0069	0.0134
Edible Oil	-0.0979	-0.0939	-0.0981
Other Food	-0.0417	-0.0428	-0.0421
Tobacco Products	-0.0481	0.1063	-0.0185
Sugar-Gur	-0.0298	-0.0314	-0.0297
Salt	-0.0239	-0.0274	-0.0245

Table A2: Percentage Changes in Household Income

Household Groups	*TM*	*TM1*	*TM2*
Professional	2.25	1.55	1.58
Services	1.86	1.21	1.25
Agricultural Labour	1.98	1.29	1.32
Small Farm	2.09	1.42	1.45
Large Farm	1.94	1.32	1.46
Worker: Skilled	1.32	0.99	0.41
Worker: Semi-Skilled	0.99	0.37	0.25
Worker: Unskilled	1.00	0.35	0.34

Estimation of Price and Income Elasticity

In order to examine the impact of macreconomic policy changes on household nutritional status, own and cross price elasticity for major food items and income elasticity of household groups are needed. While estimates of such elasticity are available for some specific years, they are not available by occupational classes as classified in the 1992/93 SAM data-base. Therefore, in order to link the estimates of the elasticity model and price and income changes generated in the CGE model, estimates of price and income elasticity are required for the eight occupational classes for 1992/93. The price and income elasticity for the major occupational groups have been estimated for 1992/93 using the food characteristics demand system (FCDS).

The FCDS Model

In the FCDS model, utility is assumed to be a function of characteristics of quantities of food consumed namely, energy, variety and tastes and of non-food purchases. The total utility derived from the three characteristics and from the non-food item is the weighted sum of the individual utilities that these food and non-food items provide. Following Bouis (1991), this can be expressed as:

$$U' = \alpha_b U_b(\beta) + \alpha_e . U_e(r) + \sum_{i=1}^{n} \alpha_{ti} U_{ti}(Q_i) + \alpha_{nf} U_{nf}(Q_{nf}) \qquad (1)$$

Where, U=total utility derived from all food and non-food items, Q =quantity of a commodity, β=a measure of energy, r=a measure of variety, U_b=utility derived from energy U_e=utility derived from variety, U_{ti} Q_I=utility derived from the taste of units of commodity I, $U_{nf}(Q_{nf})$=utility from non-food item, α_b=weight of utility from energy, α_e=weight of utility from variety, α_{ti}=weight of taste from food I, α_{nf} =weight of utility from the non-food commodity.

The utility from energy can further be expressed as

$$\beta = \sum_{i=1}^{n} \theta_i Q_i \qquad (2)$$

Where θ_i is a factor that converts quantity of the i[th] food into energy. In the model, calories have been used as proxies for the θ_i's in estimation. β is the total calories consumed which has been adjusted with adult equivalent ratio. The functional form of U_b (β) is

$$U_b(\beta) = b_2\beta + b_3\beta^2 \quad \text{where,} \quad b_2>0 \text{ and } b_3<0. \qquad (3)$$

At low levels of total energy, additional units increase utility at a decreasing rate. This functional form implies that at sufficiently high intakes of energy, utility from additional units of energy decrease marginally.

$$\beta_i = \alpha_b(b_2\theta_i + 2b_3\beta\theta_i) > 0 \text{ for low income groups} \tag{4}$$

where, $\beta_i = \dfrac{\partial U}{\partial U_b(\beta)} \cdot \dfrac{\partial U_b(\beta)}{\partial Q_i}$

and $\beta_{ij} = 2\alpha_b b_3 \theta_i \theta_j < 0$ (5)

where, $\beta_{ij} = \dfrac{\partial \beta_i}{\partial Q_j}$

The utility from taste is expressed as

$$U_{ti}(Q_i) = \log(Q_i) \tag{6}$$

$$T_i = \alpha_{ti}(1/Q_i) > 0 \tag{7}$$

where, $T_i = \dfrac{\partial U}{\partial U_{ti}(Q_i)} \dfrac{\partial U_{ti}(Q_i)}{\partial Q_i}$

$$T_{ii} = -\alpha_{ti}(1/Q_i)^2 < 0 \tag{8}$$

$$T_{ij} = 0 \tag{9}$$

Where, $T_{ij} = \dfrac{\partial U_{ti}(Q_i)}{\partial Q_i}$

The above suggests that additional unit of taste of good i increases utility but at a decreasing rate. The first order derivative is positive whilst the second order is negative. For taste across food, the second derivative is zero.

The utility from variety is defined as

$$Uc(r) = \frac{\delta}{\psi} \tag{10}$$

where, δ = nonstaple kilograms of food consumed per adult equivalent, and ψ = total kilograms of food consumed per adult equivalent. Moreover, $r_i = -\alpha_c \frac{\delta}{\psi^2} < 0$, for $i \leq s$

$$r_i = \alpha_c[(\psi - \delta)/\delta^2] > 0 \qquad \text{for } s < i \leq n \tag{11}$$

where, i= 1, 2, ... n are staple foods.

The above implies that each additional unit of a staple good reduces utility from variety and each additional unit of a non-staple good increases utility from variety.

As stipulated for energy and variety,

$$V_{ij} = 2\,\alpha_c {\delta}/{\psi^3} > 0 \qquad \text{for } i,j \leq s$$

$$V_{ij} = ({\alpha_c}/{\psi^3})[2\delta - \psi] \qquad \text{for } i \leq s \text{ and } s<j \leq n \tag{12}$$

$$V_{ij} = (({2\alpha_c}/{\psi^3})[\delta - \psi] < 0 \qquad \text{for } s<i,\ j \leq n$$

and for all $V_{ij} = V_{ji}$

Unlike the food items, no explicit functional form is specified for utility from the non-food. In order to solve the model for the (n+1) by (n+2) matrix of food demand elasticities, it is necessary with respect to utility from the non-food, only to specify the following relationship:

$$\frac{\partial(\frac{\partial U}{\partial Q_{nf}})}{\partial Q_{nf}} = \lambda \frac{P_{nf}}{Q_{nf}}[\frac{\phi}{\eta_{nf}}] \tag{13}$$

where, ϕ = money flenisility, η_{nf} = non-food income elasticity, P_{nf} = price of the non-food item, λ = lagrange multiplier or the marginal utility of income.

Solving the Model

For any food i (i = 1,2,...., n) the first order conditions give

$$P_i = \frac{\partial U}{\frac{\partial U}{\lambda}[\frac{\partial U_b}{\partial \beta}.\frac{\partial \beta}{\partial Q}]} + \frac{\partial U}{\frac{\partial U_c}{\lambda}[\frac{\partial U_c}{\partial r}.\frac{\partial r}{\partial Q_i}]} + \frac{\partial U}{\frac{\partial U_T}{\lambda}[\frac{\partial U_T}{\partial T}.\frac{\partial T}{\partial Q_i}]} \tag{14}$$

There are n equations associated with (14) and if we assume that the first food is a staple we get:

$$P_1 = \frac{\alpha_b}{\lambda}[b_2\theta_1 + 2b_3\theta_1\beta] + \frac{\alpha_c}{\lambda}[-\frac{\delta}{\psi^2}] + \frac{\alpha_{ti}}{\lambda}[\frac{1}{Q_1}] \qquad (15)$$

Thus shadow prices for energy and variety can be obtained by multiplying the coefficient outside the brackets with the first partial derivatives inside the brackets for the first and second terms in equation (15). The shadow prices sum to the retail price for each food at all income levels and the proportion of the retail price for each food accounted for by the shadow price of each characteristic will vary by income group.

With the data on food prices and food quantities and values for $\alpha_b b_2, \alpha_b b_3$, and α_c it is possible to solve the n equations represented by equation (14) for the n $\alpha_{ti}s$. In addition, given a value for $\frac{\phi}{n_{nf}}$ and data on non-food expenditures, it is possible to obtain values for the entire (n+1) by (n+1) matrix of second partial derivatives of the utility function with respect to n foods and the non-food commodities. Then, these values can be used to estimate the full matrix of (n+1) by (n+1) demand elasticities[2]. Thus four parameters along with data on prices and quantities of consumption are required to solve the model.

Data Requirement and Estimation Technique

From the above, it is clear that in order to estimate the elasticities, one needs two types of information. These include price and quantity data across various occupational groups and the values of the parameters associated with the utility function. The price and quantity data include (i) per capita quantities consumed for each of the n food items, (ii) unit price of the food items, (iii) calorie conversion rate per unit of each food item, (iv) total non-food expenditure, and (v) ratio of adult equivalent over total persons. For the present study, data on (i), (ii) and (iv) have been obtained from the Household Expenditure Survey (HES) 1991-92 of the Bangladesh Bureau of Statistics (BBS). The calorie conversion rates have been taken from the published document of the Institute of Food and Nutrition of Dhaka University. However, the adult equivalent ratio was not readily available and some `educated guesses' were made.

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[2] See, for example, Henderson and Quandt, (1980), p.25-35.

Prior knowledge about the values of the parameters of the utility function was another precondition for implementing the methodology. It is possible, however, to estimate the values of the parameters. One can rewrite equation (15) as

$$P_1 = \frac{\alpha_b}{\lambda}[b_2\theta_1 + 2b_3\theta_1\beta] + \frac{\alpha_c}{\lambda}[-\frac{\delta}{\psi^2}] + \frac{\alpha_{ti}}{\lambda}[\frac{1}{Q_1}] = a_1 + a_2(\beta) + a_3(\frac{\delta}{\psi^2}) + a_4(\frac{1}{Q_1}) \cdot \quad (16)$$

Equation (16) may be estimated to get the values of the parameters as in a system with n foods, there would be n equations to estimate with identical parameters associated with energy and variety in each of the n equations. In order to make the model operational, assumptions about the values of the parameters are made. Studies are available with reasonable values of these parameters in other countries and on the basis of the aforementioned findings, reasonable prior assumptions have been made. The assumed values of the parameters are given in MAP Technical Paper No.5.

Once the data and the values of the parameters are available, the estimation is straightforward. The first order conditions give the absolute shadow prices disaggregated by bulk, variety and taste by groups. This explains the components of shadow prices by characteristics inherent in particulars food groups. From the second order conditions, the bulk, variety and taste matrix can be deducted. The sum of bulk, variety and taste matrix will result in the overall utility matrix. Thus:

$$\beta_{ij} + r_{ij} + T_{ij} = U_{ij} \quad (17)$$

However, T_{ij} would be a diagonal matrix and for T_{ij}, i=j. Once the overall utility matrix is obtained from the second-order conditions with the prices of the commodities, the Bordered Hessain matrix can be constructed to estimate the elasticity. With five food and one non-food commodities, the Bordered Hessian matrix will look like:

$$\begin{vmatrix} \beta_{11}+r_{11}+T_{11} & \beta_{12}+r_{12} & \beta_{13}+r_{13} & \beta_{14}+r_{14} & \beta_{15}+r_{15} & 0 & -P_1 \\ \beta_{21}+r_{21} & \beta_{22}+r_{22} & \beta_{23}+r_{23} & \beta_{24}+r_{24} & \beta_{25}+r_{25} & 0 & -P_2 \\ \beta_{31}+r_{31} & \beta_{32}+r_{32} & \beta_{33}+r_{33} & \beta_{34}+r_{34} & \beta_{35}+r_{35} & 0 & -P_3 \\ \beta_{41}+r_{41} & \beta_{42}+r_{42} & \beta_{43}+r_{43} & \beta_{44}+r_{44} & \beta_{45}+r_{45} & 0 & -P_4 \\ \beta_{51}+r_{51} & \beta_{52}+r_{52} & \beta_{53}+r_{53} & \beta_{54}+r_{54} & \beta_{55}+r_{55} & 0 & -P_5 \\ 0 & 0 & 0 & 0 & 0 & f_{66} & -P_6 \\ -P_1 & -P_2 & -P_3 & -P_4 & -P_5 & -P_6 & 0 \end{vmatrix}$$

where, f_{66} implies the shadow price of the non-food item. From the overall utility matrix for a particular occupational group, own and cross price elasticities for food and non-food items can be estimated. For example, if we want to estimate the own price elasticity of food item 5 (μ_{55}) the following formula can be used:

$$\mu_{55} = \frac{P_5}{q_5}\left[\frac{D_{55}}{D} + \frac{Q_5 D_{65}}{D}\right]$$

where, P_5 = price of commodity 5, Q_5 =quantity of commodity 5, D = the determinant of the entire Bordered Hessian matrix, D_{65} = the cofactor of the element in the sixth row and fifth column.

The cross price elasticities can also be obtained from the overall utility matrix. If we want to estimate the elasticity of food item 5 with respect to price of the first commodity, the required formula is

$$\mu_{51} = \frac{P_1}{Q_5}\left[\frac{D_{15}}{D} + \frac{Q_1 D_{65}}{D}\right]$$

where, P_1 = price of commodity 1, Q_5 = quantity of commodity 5, D_{65} = the cofactor of the element in the sixth row and fifth column of the Bordered Hessian, D_{15} = the cofactor of the element in the first row and fifth column of the Bordered Hessian.

Annex 1: Estimates of Food and Income Elasticity

Table 1: Food Demand Elasticity Estimates for Professional Group

	Rice	*Wheat*	*Fish*	*Pulses*	*Beef*	*Mutton*	*Poultry*	*Fruits*	*Vegetables*	*Potato*	*Edible oil*	*Sugar*	*Gur*	*Milk*	*other food*	*Non-food*	*Income*
Rice	-0.48870	1.28522	0.01774	0.14936	-0.60960	0.05689	-0.01166	0.00580	0.01566	-0.16346	0.00338	0.00129	0.00011	0.00130	0.00098	0.00821	-0.14340
Wheat	0.11021	-1.48604	-0.23593	-0.53716	-0.04660	-0.00487	-0.01509	-0.05199	-0.15021	-0.18832	-1.02923	-0.60469	-0.77475	-0.13496	-0.00518	-0.28039	-0.59951
Fish	0.01049	1.27870	-0.91245	-0.03094	0.01018	0.00814	0.00938	0.01519	0.03062	-0.11532	-0.09155	-0.04838	-0.07049	0.01871	0.01413	0.03435	1.98373
Pulses	0.06383	0.06791	0.03147	-1.38880	-0.19923	-0.19605	-0.19773	-0.20452	-0.22413	-0.04314	-0.09070	-0.13641	0.00550	-0.21086	-0.20327	-0.15982	1.33202
Beef	-0.00185	-0.01089	0.06375	0.04110	-1.01897	-0.04070	-0.04029	-0.05617	-0.06902	-0.12958	-0.01794	-0.03139	-0.03260	-0.04122	-0.04246	-0.00633	2.08836
Mutton	0.00039	-0.00063	0.01040	-0.00023	0.01144	-1.04643	-0.05719	-0.05364	-0.00599	0.00220	-0.02515	-0.03762	-0.02951	-0.05776	-0.05790	-0.04364	2.12749
Poultry	-0.00142	0.00065	-0.03218	-0.02226	-0.03164	0.03159	-1.02933	0.00976	0.00753	-0.00210	-0.00481	-0.00728	-0.00568	-0.01040	-0.01152	-0.00613	2.12162
Fruits	0.00571	-0.00797	-0.01647	0.02759	0.02526	0.02650	-0.00134	-1.28143	-0.00274	0.00611	-0.00031	-0.00036	-0.00007	-0.00165	-0.00048	-0.00371	1.52888
Vegetbles	-0.04776	0.03227	0.15869	0.14417	0.08879	0.06893	0.00631	0.02936	-1.16772	-0.03826	0.00171	0.00201	0.00017	0.00975	0.00285	0.02231	0.92145
Potato	0.06323	-0.00970	-0.00946	0.04997	0.00076	-0.00109	-0.00280	-0.01056	-0.03111	-1.91698	-0.00920	-0.01100	-0.00341	-0.04733	-0.01391	-0.10428	1.60620
Edible oil	0.14816	0.02135	0.04029	0.02683	0.03429	0.03223	0.00079	0.00369	0.01023	-0.02072	-1.64815	0.00389	-0.00022	0.02014	0.00586	0.04703	0.81253
Sugar	0.04593	0.00109	0.01786	0.01852	0.02250	-0.00070	-0.00062	-0.00251	-0.00724	0.01773	-0.00084	-1.45133	-0.00030	-0.00595	-0.00175	-0.01313	1.22592
Gur	0.01077	0.00224	0.00585	0.00469	0.00429	0.00378	0.00017	0.00081	0.00224	-0.00451	0.00024	0.00030	-1.64120	0.00452	0.00132	0.01034	0.84012
Milk	0.01047	-0.01155	0.05625	0.05887	0.07085	0.07352	0.00188	-0.00776	-0.02220	0.05315	-0.00244	-0.00287	-0.00032	-1.11203	-0.00038	-0.00287	1.86099
oth food	-0.00524	0.00178	0.00357	0.02906	0.03796	0.03723	-0.00049	0.00220	0.00617	-0.01331	0.00069	0.00082	0.00019	0.00368	-1.42050	0.03128	2.07219
Nonfood	0.00022	-0.04370	0.37857	-0.54659	0.44582	0.46488	0.00581	-0.02570	-0.07201	0.15523	-0.00803	0.00957	-0.00225	-0.04292	-0.01261	-0.40208	1.36533

Table 2: Food Demand Elasticity Estimates for Services Group

	Rice	Wheat	Fish	Pulses	Beef	Mutton	Poultry	Fruits	Vegetables	Potato	Edible oil	Sugar	Gur	Milk	other food	Non-food	Income
Rice	-0.14328	0.70006	0.00019	0.00498	-0.59477	0.01714	-0.00363	0.00098	0.02200	-0.07564	-0.00017	-0.00009	-0.00260	0.00047	0.00010	0.00177	-0.05817
Wheat	0.02145	-0.79434	-0.25568	-0.64060	-0.14206	-0.11969	-0.12022	0.00147	0.23585	-0.17919	-0.90642	-0.58702	-0.00022	-0.10870	-0.07308	-0.20915	-0.13912
Fish	0.07196	0.00113	-1.01965	-0.01537	-0.00124	-0.00194	-0.00164	0.00399	0.07177	-0.02922	-0.02365	-0.01451	-0.61986	0.00214	0.00013	0.01074	1.37333
Pulses	0.03642	0.01881	-0.00081	-1.09793	-0.04833	-0.04783	-0.04836	-0.06676	-0.37442	-0.02098	0.02042	-0.00798	-0.13588	-0.05902	-0.05346	-0.04250	0.32777
Beef	0.01549	0.00294	0.01747	0.00407	-1.01375	-0.00362	-0.00384	-0.02225	-0.15395	-0.02765	0.03717	0.01902	0.96751	-0.01332	-0.00741	0.00360	1.54269
Mutton	0.00107	0.00086	0.00305	-0.00001	0.00351	-1.01515	-0.01722	-0.01920	-0.01063	-0.00349	0.00246	-0.00522	0.57183	-0.01795	-0.01836	-0.01373	1.59856
Poultry	0.00582	-0.00187	0.00714	0.00183	0.00755	0.00765	-1.01428	-0.00356	-0.01281	-0.00069	0.00048	-0.00107	0.12335	-0.00333	-0.00380	-0.00193	1.59267
Fruits	-0.01268	0.01177	0.00616	0.00925	0.00695	0.00693	-0.00020	-1.20194	-0.00366	0.00163	0.00001	-0.00002	0.00208	-0.00023	-0.00006	-0.00098	1.25611
Vegetables	-0.02660	-0.09951	0.23431	0.34515	0.15942	0.13293	0.00164	0.00895	-1.34762	-0.01004	-0.00010	0.00008	-0.01425	0.00141	0.00038	0.00596	3.58510
Potato	-0.00936	0.03104	0.00265	0.01066	0.00365	0.00253	-0.00052	-0.00236	-0.05604	-1.57073	-0.00070	-0.00175	0.05010	-0.01231	-0.00309	-0.04744	1.97298
Edible oil	0.09845	-0.00515	-0.00698	-0.04879	-0.00275	-0.00294	0.00014	0.00075	0.01560	-0.00660	-1.11333	0.00025	-0.03541	0.00357	0.00096	0.01534	0.12629
Sugar	0.01309	0.00385	0.00027	-0.00709	0.00172	-0.00017	-0.00006	-0.00026	-0.00616	0.00284	-0.00003	-1.05484	0.01566	-0.00100	-0.00028	-0.00396	0.47852
Gur	0.04513	-0.00218	0.00066	-0.02426	-0.01361	-0.01454	0.00006	0.00037	0.00721	-0.00283	-0.00015	-0.00004	-3.85367	0.00040	0.00010	0.00170	1.14050
Milk	-0.01294	0.01716	0.01047	0.01101	0.01225	0.01237	-0.00029	-0.00137	-0.03179	0.01450	0.00012	-0.00013	0.02016	-1.16009	-0.00013	-0.00175	1.27355
oth food	0.00595	-0.00350	0.00043	0.00402	0.00921	0.00920	0.00006	0.00029	0.00663	-0.00294	-0.00001	0.00004	-0.00351	0.00043	-1.07139	0.00861	1.64133
Non-food	0.15792	0.09077	0.56043	-0.46055	0.64387	0.67090	-0.00153	-0.00766	-0.16652	0.07147	0.00061	-0.00077	0.09245	-0.01081	-0.00287	-0.20100	1.05043

Table 3: Food Demand Elasticity Estimates for Large Farmers

	Rice	*Wheat*	*Fish*	*Pulses*	*Beef*	*Mutton*	*Poultry*	*Fruits*	*Vegetables*	*Potato*	*Edible oil*	*Sugar*	*Gur*	*Milk*	*other food*	*Non-food*	*Income*
Rice	-0.20366	0.82481	0.00241	0.03150	-0.55388	0.01172	-0.00268	0.00055	0.00596	-0.09545	0.00075	0.00007	0.00002	0.00046	0.00012	-0.00218	-0.05369
Wheat	0.03856	-0.79968	-0.18192	-0.52108	-0.05626	-0.03111	-0.03814	-0.07205	-0.31368	-0.11730	-0.59833	-0.38318	-0.66091	-0.10219	-0.02129	0.20481	-0.27253
Fish	0.01754	0.17379	-1.00061	-0.01258	0.00099	0.00096	0.00111	0.00130	0.01344	-0.03189	-0.01647	-0.00999	-0.01902	0.00212	0.00217	-0.01257	1.67776
Pulses	0.03381	0.02125	-0.00785	-1.07954	-0.05501	-0.05433	-0.05488	-0.07240	-0.17101	-0.04299	-0.02102	-0.03533	0.00144	-0.06391	-0.06065	0.04656	0.72295
Beef	0.00134	-0.00040	0.01178	0.00618	-1.01963	-0.00952	-0.00977	-0.02831	-0.07558	-0.04973	0.00291	-0.00404	-0.00255	-0.01673	-0.01457	-0.00268	1.83793
Mutton	0.00030	-0.00006	0.00237	-0.00003	0.00263	-1.01776	-0.01175	-0.01265	-0.00223	-0.00597	-0.00470	-0.00741	-0.00404	-0.01227	-0.01230	0.00921	1.90430
Poultry	0.00059	0.00016	0.00743	0.00382	0.00755	0.00763	-1.01744	-0.00248	-0.00392	-0.00051	-0.00101	-0.00163	-0.00075	-0.00251	-0.00271	0.00140	1.88415
Fruits	0.00186	-0.00093	0.00524	0.00797	0.00590	0.00548	-0.00016	-1.20019	-0.00118	0.00172	-0.00004	-0.00002	-0.00001	-0.00021	-0.00006	0.00103	1.26252
Vegetables	-0.00050	0.00993	0.12824	0.17114	0.08382	0.06448	0.00174	0.00677	-1.36740	-0.00900	0.00021	0.00011	0.00004	0.00105	0.00031	-0.00535	1.27963
Potato	0.02481	0.00254	-0.00963	0.02481	0.01027	0.00770	-0.00056	-0.00179	-0.02094	-1.33721	-0.00256	-0.00147	-0.00110	-0.01195	-0.00366	0.05801	1.77343
Edible oil	0.04520	-0.00230	0.00997	-0.00280	0.00978	0.00939	0.00012	0.00044	0.00462	-0.00658	-1.04110	0.00038	0.00012	0.00370	0.00109	-0.01894	0.67168
Sugar	0.00674	0.00002	-0.00277	0.00101	0.00329	-0.00006	-0.00004	-0.00013	-0.00149	0.00225	-0.00006	-1.04530	-0.00002	-0.00080	-0.00025	0.00396	1.06314
Gur	0.00990	0.00076	0.00081	0.00083	0.00180	0.00141	0.00007	0.00025	0.00266	-0.00380	0.00009	0.00005	-1.09344	0.00026	0.00008	-0.00134	0.30513
Milk	0.00450	0.00142	0.01384	0.01371	0.01565	0.01535	-0.00025	-0.00081	-0.00926	0.01391	-0.00033	-0.00017	-0.00006	-1.09985	-0.00014	0.00229	1.57652
other food	-0.00020	-0.00034	0.00053	0.00493	0.00674	0.00656	0.00006	0.00023	0.00251	-0.00363	0.00009	0.00005	0.00003	0.00044	-1.07524	-0.00828	1.79429
Non-food	-0.01321	0.01525	0.67977	-0.61538	0.76234	0.79242	-0.00162	-0.00605	-0.06210	0.08744	-0.00222	-0.00127	-0.00082	-0.01086	-0.00334	-0.13755	1.23507

Table 4: Food Demand Elasticity Estimates for Skilled Workers

	Rice	*Wheat*	*Fish*	*Pulses*	*Beef*	*Mutton*	*Poultry*	*Fruits*	*Vegetables*	*Potato*	*Edible oil*	*Sugar*	*Gur*	*Milk*	*other food*	*Non-food*	*Income*
Rice	-0.27339	0.83412	0.00288	-0.03570	-0.52768	0.01913	-0.00313	0.00093	0.00864	-0.08334	0.00081	0.00013	0.00003	0.00024	0.00015	0.00242	-0.05408
Wheat	0.06484	-0.83616	-0.15983	0.46232	-0.05402	-0.03412	-0.03012	-0.06175	-0.27211	-0.24281	-0.64116	-0.40381	-0.57926	-0.10293	-0.01727	-0.15213	-0.23684
Fish	0.02438	0.18686	-1.00605	-0.01569	0.00151	0.00084	0.00128	0.00206	0.01931	-0.04379	-0.02520	-0.01503	-0.02321	0.00034	0.00276	0.01556	1.61764
Pulses	0.03743	0.01967	0.00844	-1.08108	-0.05954	-0.05850	-0.05902	-0.07348	-0.20166	-0.04670	-0.01968	-0.03643	0.00144	-0.06741	-0.06381	-0.04920	0.81021
Beef	0.00285	-0.00050	0.01934	0.01077	-1.01421	-0.01027	-0.01025	-0.02260	-0.07066	-0.04415	0.00161	-0.00477	-0.00383	-0.01848	-0.01333	0.00081	1.76485
Mutton	0.00047	-0.00006	0.00277	-0.00003	0.00305	-1.02116	-0.01930	-0.01982	-0.00380	-0.00900	-0.00660	-0.01147	-0.00760	-0.01885	-0.01987	-0.01482	1.80090
Poultry	0.00064	0.00008	0.00667	0.00367	0.00685	0.00686	-1.01673	-0.00289	-0.00554	-0.00061	-0.00101	-0.00179	-0.00113	-0.00278	-0.00313	-0.00161	1.81699
Fruits	0.00236	-0.00095	0.00729	0.00963	0.00802	0.00799	-0.00016	-1.21186	-0.00102	0.00128	-0.00003	-0.00002	-0.00001	-0.00011	-0.00005	-0.00077	1.24789
Vegetables	0.00344	0.00721	0.14092	0.16970	0.09529	0.07988	0.00119	0.00805	-1.64459	-0.01118	0.00027	0.00020	0.00006	0.00090	0.00046	0.00663	1.54000
Potato	0.03613	-0.00121	0.01034	0.02541	0.00968	0.00853	-0.00046	-0.00255	-0.02540	-1.49545	-0.00241	-0.00191	-0.00116	-0.00791	-0.00380	-0.05115	1.01663
Edible oil	0.07126	0.00418	0.01006	-0.00146	0.00957	0.00905	0.00011	0.00068	0.00631	-0.00766	-1.05105	0.00059	0.00016	0.00263	0.00135	0.01974	0.54493
Sugar	0.01335	0.00032	0.00380	0.00183	0.00449	-0.00009	-0.00005	-0.00027	-0.00261	0.00336	-0.00009	-1.05502	-0.00003	-0.00067	-0.00034	-0.00462	0.95337
Gur	0.00955	0.00071	0.00061	0.00096	0.00174	0.00151	0.00004	0.00024	0.00224	-0.00272	0.00007	0.00005	-1.09205	0.00027	0.00014	0.00200	0.46559
Milk	0.00431	-0.00084	0.00819	0.00942	0.00912	0.00914	-0.00015	-0.00086	-0.00841	0.01085	-0.00026	-0.00020	-0.00006	-1.16527	-0.00012	-0.00164	1.29678
other food	-0.00013	0.00027	0.00060	0.00616	0.00885	0.00863	0.00006	0.00035	0.00327	-0.00402	0.00011	0.00008	0.00004	0.00035	-1.08128	0.00644	1.72682
Non-food	-0.01581	0.01622	0.66918	-0.54650	0.74621	0.76525	-0.00121	-0.00762	-0.06942	0.08248	-0.00221	-0.00175	-0.00090	-0.00755	-0.00371	-0.14732	1.17981

Table 5: Food Demand Elasticity Estimates for Semi-Skilled Workers

	Rice	Wheat	Fish	Pulses	Beef	Mutton	Poultry	Fruits	Vegetables	Potato	Edible oil	Sugar	Gur	Milk	other food	Non-food	Income
Rice	-0.28268	0.81323	0.00413	0.03922	-0.72246	0.00587	-0.00113	0.00036	0.00661	-0.10022	0.00094	0.00013	0.00002	0.00048	0.00007	0.00172	-0.06569
Wheat	0.08139	-0.83493	-0.18154	-0.46299	-0.05899	-0.02824	-0.03536	-0.07003	-0.34676	-0.23158	-0.60491	-0.38218	-0.61110	-0.12243	-0.01104	-0.18521	0.21521
Fish	0.02230	0.18666	-1.00367	-0.02062	0.00003	0.00102	0.00089	0.00079	0.03009	-0.06571	-0.03210	-0.01946	-0.03366	0.00261	0.00336	0.02320	1.65399
Pulses	0.04195	0.02374	0.01142	-1.07397	-0.06081	-0.06057	-0.06093	-0.07931	-0.19835	-0.04875	-0.02396	-0.03984	0.00157	-0.07372	-0.06534	-0.05308	0.84454
Beef	0.00092	0.00006	0.00613	0.00357	-1.03242	-0.01363	-0.01405	-0.03267	-0.07498	-0.06120	-0.00157	-0.00837	-0.00742	-0.02282	-0.01642	0.00158	1.77321
Mutton	0.00013	-0.00003	0.00100	-0.00001	0.00110	-1.01993	-0.00587	-0.00659	-0.00172	-0.00323	-0.00232	-0.00375	-0.00239	-0.00644	-0.00618	-0.00484	1.88493
Poultry	0.00030	0.00008	0.00330	0.00189	0.00327	0.00336	-1.02397	-0.00101	-0.00174	-0.00022	-0.00040	-0.00067	-0.00036	-0.00102	-0.00116	-0.00059	1.85238
Fruits	0.00176	-0.00081	0.00396	0.00571	0.00505	0.00431	-0.00006	-1.22585	-0.00071	0.00083	-0.00002	-0.00001	-0.00001	-0.00011	-0.00002	-0.00050	1.18318
Vegetables	0.00160	0.01056	0.14674	0.15981	0.10504	0.07740	0.00079	0.00503	-1.55904	-0.00788	0.00021	0.00012	0.00005	0.00105	0.00021	0.00470	1.68111
Potato	0.03173	-0.00182	0.00896	0.02363	0.01200	0.00631	-0.00027	-0.00153	-0.02913	-1.46340	-0.00285	-0.00163	-0.00086	-0.01383	-0.00272	-0.06045	1.77868
Edible oil	0.06528	0.00528	0.01322	0.00299	0.01201	0.01138	0.00007	0.00044	0.00770	-0.00901	-1.04078	0.00052	0.00020	0.00463	0.00091	0.02081	0.61087
Sugar	0.00953	0.00026	0.00349	0.00212	0.00422	-0.00007	-0.00002	-0.00013	-0.00252	0.00300	0.00008	-1.04790	-0.00006	-0.00123	-0.00024	-0.00541	1.02597
Gur	0.00970	0.00103	0.00081	0.00159	0.00191	0.00149	0.00003	0.00017	0.00303	-0.00355	0.00010	0.00005	-1.09101	0.00040	0.00008	0.00179	0.38102
Milk	0.00678	-0.00181	0.01417	0.01535	0.01727	0.01599	-0.00014	-0.00084	-0.01578	0.01881	-0.00051	-0.00028	-0.00011	-1.14968	-0.00010	-0.00213	1.44271
other food	-0.00024	0.00023	0.00039	0.00469	0.00710	0.00713	0.00002	0.00014	0.00244	-0.00287	0.00008	0.00004	0.00002	0.00039	-1.06919	0.01123	1.85463
Non-food	-0.01697	-0.02018	0.66382	-0.58073	0.73375	0.78165	-0.00077	-0.00478	-0.08376	0.09771	-0.00273	-0.00155	-0.00076	-0.01338	-0.00265	-0.14986	1.22408

Table 6: Food Demand Elasticity Estimates for UnSkilled Workers

	Rice	Wheat	Fish	Pulses	Beef	Mutton	Poultry	Fruits	Vegetables	Potato	Edible oil	Sugar	Gur	Milk	other food	non-food	Income
Rice	-0.24795	0.86678	0.00439	0.03061	-0.54006	0.01075	-0.00379	0.00060	0.01066	-0.11552	0.00077	0.00007	0.00002	0.00010	0.00004	0.00148	-0.03640
Wheat	0.06850	-0.83146	-0.18020	-0.48377	-0.05321	-0.03368	-0.03122	-0.08950	-0.51951	-0.19682	-0.62344	-0.35847	-0.35466	-0.07970	-0.02740	-0.21576	-0.30006
Fish	0.01967	0.17046	-1.00679	-0.01619	0.00238	0.00245	0.00288	0.00161	0.03329	-0.05809	-0.02513	-0.01295	-0.01285	0.00225	0.00312	0.02307	1.67634
Pulses	0.03501	0.01880	0.00914	-1.07366	-0.05502	-0.05513	-0.05558	-0.06224	-0.20714	-0.02195	-0.01856	-0.03530	0.00081	-0.05717	-0.05829	-0.04930	0.80856
Beef	0.00132	-0.00082	0.01043	0.00545	-1.01821	-0.01141	-0.01141	-0.02414	-0.08028	-0.04363	-0.00010	-0.00631	-0.00677	-0.01535	-0.01601	0.00209	1.85985
Mutton	0.00040	-0.00007	0.00327	-0.00003	0.00368	-1.01586	-0.01083	-0.00966	-0.00289	-0.00206	-0.00359	-0.00668	-0.00669	-0.01019	0.01055	-0.00853	1.91755
Poultry	0.00054	0.00001	0.00716	0.00369	0.00754	0.00769	-1.01191	-0.00298	-0.00651	-0.00072	-0.00119	-0.00228	-0.00228	-0.00338	-0.00358	-0.00197	1.92916
Fruits	0.00195	-0.00061	0.00433	0.00593	0.00523	0.00501	-0.00013	-1.24332	-0.00141	0.00144	-0.00003	-0.00001	-0.00001	-0.00007	-0.00003	-0.00086	1.16548
Vegetables	0.01598	0.00670	0.16283	0.18848	0.10883	0.09084	0.00137	0.00789	-1.81977	-0.01115	0.00020	0.00011	0.00009	0.00053	0.00018	0.00663	1.98224
Potato	0.03250	-0.00077	0.00629	0.01922	0.00714	0.00516	-0.00049	-0.00201	-0.04005	-1.49088	-0.00260	-0.00152	-0.00142	-0.00640	-0.00257	-0.07085	1.70588
Edible oil	0.05080	0.00311	0.00959	0.00082	0.00909	0.00886	0.00009	0.00047	0.00803	-0.00793	-1.03863	0.00040	0.00034	0.00198	0.00066	0.02511	0.57453
Sugar	0.00609	0.00015	0.00281	0.00137	0.00334	-0.00004	-0.00003	-0.00011	-0.00214	0.00223	-0.00005	-1.04096	-0.00006	-0.00041	-0.00016	-0.00478	1.11360
Gur	0.00459	0.00033	0.00036	0.00136	0.00275	0.00271	0.00002	0.00011	0.00198	-0.00198	0.00004	0.00002	-1.04664	0.00011	0.00004	0.00133	1.10090
Milk	0.00204	-0.00043	0.00669	0.00540	0.00784	0.00787	-0.00009	-0.00037	-0.00714	0.00742	-0.00014	-0.00007	-0.00006	-1.09497	-0.00004	-0.00119	1.59829
other food	0.00006	0.00011	0.00034	0.00223	0.00308	0.00302	0.00003	0.00014	0.00247	-0.00246	0.00005	0.00003	0.00002	0.00012	-1.08931	0.00442	1.70253
non-food	-0.00828	-0.01780	0.65709	-0.59910	0.74924	0.77453	-0.00137	-0.00678	-0.11570	0.11419	-0.00227	-0.00128	-0.00116	-0.00591	-0.00224	-0.16537	1.24282

Table 7: Food Demand Elasticity Estimates for Small Farmers

	Rice	Wheat	Fish	Pulses	Beef	Mutton	Poultry	Fruits	Vegetables	Potato	Edible oil	Sugar	Gur	Milk	other food	Non-food	Income
Rice	-0.23019	0.87486	0.00478	0.01984	-0.10603	0.00249	-0.00216	0.00093	0.01515	-0.12033	0.00071	0.00003	0.00001	0.00033	0.00004	0.00148	-0.037
Wheat	0.06421	-0.83591	-0.17861	-0.56703	-0.01212	-0.03559	-0.03493	-0.10122	-0.64174	-0.08160	-0.58062	-0.38701	-0.60866	-0.10369	-0.02388	-0.24132	-0.249
Fish	0.01601	0.15553	-1.00690	-0.01488	0.00049	0.00195	0.00224	0.00218	0.03766	-0.04971	-0.01684	-0.01064	-0.01866	0.00277	0.00295	0.02279	1.71927
Pulses	0.03347	0.01487	0.00468	-1.09081	-0.01066	-0.05029	-0.05060	-0.05280	-0.20896	-0.00933	-0.01732	-0.02862	0.00084	-0.05080	-0.05202	-0.04540	0.60586
Beef	0.00012	-0.00026	0.00283	0.00105	-1.02180	-0.00730	-0.00736	-0.02048	-0.09160	-0.03375	0.00533	-0.00048	0.00245	-0.01144	-0.01111	0.00461	0.4016
Mutton	0.00024	-0.00004	0.00188	-0.00002	0.00045	-1.01765	-0.00251	-0.00229	-0.00362	0.00236	-0.00099	-0.00144	-0.00075	-0.00249	-0.00249	-0.00360	1.94411
Poultry	0.00038	0.00004	0.00474	0.00185	0.00106	0.00505	-1.01594	-0.00161	-0.00425	-0.00045	-0.00079	-0.00122	-0.00059	-0.00185	-0.00207	-0.00112	1.94699
Fruits	0.00247	-0.00090	0.00450	0.00714	0.00121	0.00560	-0.00013	-1.26575	-0.00119	0.00111	-0.00002	-0.00001	-0.00001	-0.00008	-0.00002	-0.00066	1.09789
Vegetables	0.01796	0.00764	0.16948	0.23608	0.02510	0.09878	0.00109	0.00900	-1.93133	-0.01433	0.00030	0.00009	0.00010	0.00104	0.00025	0.00855	1.11297
Potato	0.02193	-0.00135	0.00285	0.01185	0.00102	0.00413	-0.00029	-0.00206	-0.03483	-1.41366	-0.00283	-0.00105	-0.00143	-0.00943	-0.00247	-0.07296	0.79068
Edible oil	0.04236	0.00205	0.00918	-0.00609	0.00208	0.00977	0.00006	0.00049	0.00787	-0.00722	-1.03793	0.00021	0.00024	0.00239	0.00058	0.01974	0.71836
Sugar	0.00392	0.00003	0.00154	0.00004	0.00041	-0.00003	-0.00001	-0.00010	-0.00162	0.00153	-0.00004	-1.04232	-0.00004	-0.00054	-0.00014	-0.00433	1.06682
Gur	0.00967	0.00065	0.00072	-0.00049	0.00038	0.00160	0.00004	0.00029	0.00474	-0.00435	0.00009	0.00003	-1.08146	0.00011	0.00003	0.00092	0.44095
Milk	0.00311	-0.00074	0.00819	0.00646	0.00208	0.00994	-0.00010	-0.00073	-0.01222	0.01152	-0.00025	-0.00007	-0.00008	-1.11363	-0.00008	-0.00261	1.54336
other food	0.00000	0.00013	0.00032	0.00198	0.00072	0.00333	0.00002	0.00016	0.00266	-0.00246	0.00005	0.00002	0.00002	0.00018	-1.08194	0.00688	1.77519
Non-food	-0.00780	-0.01568	0.67590	-0.57644	0.16162	0.78506	-0.00104	-0.00774	-0.12343	0.11288	-0.00246	-0.00081	-0.00099	-0.00852	-0.00216	-0.15384	1.26932

Table 8: Food Demand Elasticity Estimates for Agricultural labourers

	Rice	*Wheat*	*Fish*	*Pulses*	*Beef*	*Mutton*	*Poultry*	*Fruits*	*Vegetables*	*Potato*	*Edible oil*	*Sugar*	*Gur*	*Milk*	*other food*	*Non-food*	*Income*
Rice	-0.25005	0.84083	0.00570	0.03797	-0.51075	-0.01297	0.00138	0.00771	0.03807	-0.17041	0.00085	0.00018	0.00006	0.00045	0.00005	0.00185	-0.07457
Wheat	0.06214	-0.84163	-0.19628	-0.50579	-0.04156	0.04821	-0.02547	-0.18306	-0.75382	0.06802	-0.53564	-0.28023	-0.58566	-0.11036	-0.01288	-0.33699	-0.22922
Fish	0.01246	0.21717	-0.97979	-0.01448	0.00192	-0.00447	0.00246	0.00803	0.03633	-0.06428	-0.01841	-0.00740	-0.02122	0.00294	0.00365	0.02961	1.87759
Pulses	0.03120	0.01630	0.01142	-1.06012	-0.06944	0.14689	-0.07039	-0.08022	-0.18060	-0.01569	-0.03218	-0.05215	0.00143	-0.07096	-0.07263	-0.06311	0.87271
Beef	0.00026	-0.00033	0.00596	0.00302	-1.01753	0.02945	-0.01405	-0.02147	-0.05636	-0.04831	-0.00612	-0.01062	-0.00890	-0.01750	-0.01564	0.00373	2.06895
Mutton	-0.00005	-0.00001	-0.00126	-0.00001	-0.00135	2.13503	-0.00620	-0.00612	-0.00152	-0.00106	-0.00272	-0.00449	-0.00219	-0.00581	-0.00629	-0.00493	1.45681
Poultry	0.00011	0.00011	0.00569	0.00286	0.00596	-0.01274	-1.01216	0.00125	0.00209	-0.00013	0.00059	0.00098	0.00045	0.00124	0.00138	0.00095	2.12382
Fruits	0.00902	-0.00471	0.02027	0.02101	0.02548	-0.05260	-0.00030	-1.18101	-0.00114	0.00128	-0.00002	-0.00003	-0.00001	-0.00008	-0.00002	-0.00077	1.66097
Vegetables	0.01050	0.01941	0.14978	0.15894	0.10291	-0.19111	0.00118	0.03038	-1.64767	-0.04257	0.00082	0.00090	0.00045	0.00282	0.00071	0.02553	1.05236
Potato	0.02386	-0.00411	0.00473	0.01554	0.00784	-0.01392	-0.00031	-0.00808	-0.03973	-1.30151	-0.00316	-0.00351	-0.00152	-0.01101	-0.00277	-0.10168	0.81313
Edible oil	0.03307	0.00243	0.01477	0.00735	0.01413	-0.02950	0.00006	0.00156	0.00765	-0.00866	-1.01972	0.00094	0.00047	0.00295	0.00074	0.02661	0.86206
Sugar	0.00965	-0.00029	0.01051	0.00591	0.01204	0.00015	-0.00004	-0.00101	-0.00497	0.00556	-0.00011	-1.02090	-0.00009	-0.00056	-0.00014	-0.00518	1.47936
Gur	0.00971	0.00121	0.00106	0.00301	0.00323	-0.00633	0.00005	0.00122	0.00603	-0.00682	0.00013	0.00014	-1.06852	0.00037	0.00009	0.00333	0.57644
Milk	0.00380	-0.00159	0.01155	0.00887	0.01392	-0.02931	-0.00010	-0.00261	-0.01284	0.01437	-0.00028	-0.00030	-0.00015	-1.08308	-0.00011	-0.00408	1.79187
other food	-0.00030	0.00029	0.00026	0.00390	0.00722	-0.01531	0.00002	0.00056	0.00274	-0.00308	0.00006	0.00006	0.00003	0.00020	-1.03089	0.00861	2.10481
Non-food	-0.00657	-0.02512	0.61632	-0.66035	0.70706	-1.52619	-0.00118	-0.03085	-0.15186	0.17147	-0.00324	-0.00358	-0.00166	-0.01121	-0.00281	-0.23231	1.36947

Annex-2

A General Equilibrium Model of Bangladesh Economy (The Core Model)

The Model Structure

Production and Supply

The production structure is represented by a set of nested functions. Domestic output is a Cobb-Douglas function of value added and composite intermediate inputs. The production technology is described by the following equation:

$$X_i = AX_i \prod_i V_i^{\lambda_i} \cdot IN_i^{(1-\lambda_i)} \qquad (1.1)$$

where, X_i is sectoral output. AX_i and λ_i are the production function shift and share parameters respectively. V_i is sectoral value added and IN_i is aggregation index of intermediate inputs. The composite intermediate input demand function is derived from the first order condition of equation (1.1);

$$IN_i = V_i \cdot [\frac{PV_i \cdot (1-\lambda_i)}{PN_i \cdot \lambda_i}] \qquad (1.2)$$

where, PV_i and PN_i are the value added and composite intermediate input prices respectively.

The value added is a CES aggregate of nine factor inputs which includes capital and eight different categories of labour inputs. The value added function is therefore specified as;

$$V_i = AV_i \cdot [\sum_f \alpha_{if} \cdot FD_{if}^{-\mu_i}]^{\frac{-1}{\mu_i}} \qquad (1.3)$$

where, AV_i and α_{if} are value added function shift and share parameters respectively. μ_i denotes the elasticities of substitution between factors. FD_{if} shows sectoral factors. By profit maximisation with respect to (1.3), the factor demand function is derived as:

$$FD_{if} = V_i \cdot [\frac{\alpha_{if} \cdot PV_i}{AV_i^{\mu_i} \cdot W_f \cdot \varpi_{if}}]^{\frac{1}{1+\mu_i}} \qquad (1.4)$$

where, W_f is the average return of factor f and ϖ_{if} is a sector-specific parameter derived from base year data which captures the fact that in a developing economy factor returns generally differ across sectors.

Prices

Domestic price of imports

On the import side we retain the price-taker small-country assumption of classical trade theory. This implies that the domestic price of import, PM_i is determined exogenously and is linked to the world price in dollars, $\overline{PWM_i}$ by:

$$PM_i = \overline{PWM_i} \cdot ER \cdot (1 + tm_i + st_i) \tag{1.5}$$

where tm_i and st_i are the tariff and sales tax rates on sector i and ER is the nominal exchange rate between US dollars and Bangladesh currency, taka.

Domestic price of exports

On the export side, Bangladesh is assumed to have some market power. In such a situation both the domestic price of exports and the world price of Bangladeshi exports are endogenous. The domestic price of exports is defined as a function of world price of exports PWE_i, and the nominal exchange rate, ER:

$$PE_i = PWE_i \cdot ER \tag{1.6}$$

The world prices of Bangladeshi exports are determined by domestic production costs of exports, and the exchange rate policy.

Composite price

The composite or unit price is defined by the following equation:

$$P_i = \frac{PD_i \cdot D_i + PM_i \cdot M_i}{Q_i} \tag{1.7}$$

where, D_i and M_i are the domestic and imported goods respectively. PD_i is the price of domestic goods.

Sales or Activity prices

The sales or activity price is composed of domestic price of domestic sales and domestic price of exports activities;

$$PX_i = \frac{PD_i \cdot (1 - td_i) \cdot D_i + PE_i \cdot E_i}{X_i} \tag{1.8}$$

where, td_i is the production or excise tax on sector i.

Composite intermediate input price

The composite intermediate input price is specified by the following equation:

$$PN_i = \sum_j \tau_{ji} \cdot P_j \tag{1.9}$$

where, τ_{ij} are the input-output coefficients.

Value-added price

The value-added price is defined as:

$$PV_i = \frac{PX_i \cdot X_i - PN_i \cdot IN_i}{V_i} \tag{1.10}$$

Composite capital good price

The composite capital good price is defined as:

$$PK_i = \sum_j \kappa_{ji} \cdot P_j \tag{1.11}$$

where, κ_{ij} is a capital composition matrix.

Imports and Exports

Imports

In this model the Armington specification is adopted because the perfect substitution assumption seems unrealistic for two reasons. First, in Bangladesh there are quality differences between imports and domestic substitutes for most products. Second, at a high level of aggregation in the model, each sector represents a bundle of different goods. For example the machinery sector includes goods which are produced in Bangladesh (i.e. machine tools) and others (i.e. heavy machinery) which are not domestically produced. It is therefore reasonable to suggest that these two goods are not perfect substitutes; rather they are imperfect substitutes.

Thus for each commodity category an "aggregate" or composite commodity Q_i is defined, which is a CES function of imports M_i and domestic good D_i. Domestic consumers are assumed to have a CES utility function over these two goods:

$$Q_i = AQ_i \cdot [\delta_i \cdot M_i^{-\rho_i} + (1-\delta_i) \cdot D_i^{-\rho_i}]^{-1/\rho_i} \tag{1.12}$$

where, AQ_i and δ_i are shift and share parameters respectively and σ_i, elasticity of substitution is given by $\sigma_i = \dfrac{1}{1+\rho_i}$. This formulation implies that consumers will choose a mix of M_i and D_i depending on their relative prices. Minimising the cost of obtaining a 'unit of utility', subject to (1 12) yields the following import demand function;

$$M_i = D_i \cdot [\frac{PD_i \cdot \delta_i}{PM_i \cdot (1-\delta_i)}]^{\sigma_i} \tag{1.13}$$

As a result of this specification, PD_i is no longer equal to PM_i and PD_i is endogenously determined in the model.

Exports

As mentioned earlier, on the export side Bangladesh is assumed have some market power for exports. This assumption is particularly relevant for traditional exports, such as jute and jute products, where Bangladeshi exports are significant and where Bangladesh has some market power. For other sectors, Bangladesh may not have such market power. However, given such a high level sectoral aggregation it is difficult to identify sectors with and without market power. Thus, a downward sloping world demand curve for all exports is assumed. The export demand function can be shown as:

$$E_i = E_i^0 \cdot [\frac{PWE_i}{\overline{PWSE_i}}]^{\eta_i} \tag{1.14}$$

where, E_i^0 is a constant, η_i is the price elasticity of export demand and $\overline{PWSE_i}$ is world price of goods which are close substitutes of Bangladeshi exports.

We postulate a constant elasticity of transformation (CET) function between domestically consumed goods D_i and exported goods E_i for total supply:

$$X_i = AT_i \cdot [\gamma_i \cdot E_i^{\phi_i} + (1-\gamma_i) \cdot D_i^{\phi_i}]^{1/\phi_i} \tag{1.15}$$

where X_i is domestic output, AT_i and γ_i are constant and the elasticity of transformation is given by $\psi_i = \frac{1}{1-\phi_i}$. Maximising revenue from given a output, subject to equation (2.15) yields the export supply function as:

$$E_i = D_i \cdot [\frac{PE_i \cdot (1-\gamma_i)}{PD_i \cdot (1-td_i) \cdot \gamma_i}]^{\psi_i} \tag{1.16}$$

The treatment of imports and exports allows two-way trade (that is simultaneous exports and imports, known as cross-hauling) at the sectoral level, again reflecting empirical realities in developing countries. Similar reasons were put forward by Condon et al (1986) to model the foreign trade regime of Cameroon based on CES and CET specifications.

Incomes

Household Income

The household income from factors is specified as;

$$YF_h = \sum_f \Phi_{hf} \cdot Y_f \tag{1.17}$$

where, YF_h, Φ_{hf} and Y_f define household income from factors, the factors to households allocation matrix, and income by factors, respectively. The following equation is used to calculate factor income:

$$Y_f = \prod_i W_f \cdot \varpi_{if} \cdot FD_{if} \tag{1.18}$$

Besides factor incomes, the households also receive remittances from abroad, dividend income from corporations, direct transfers from government and net transfer of resources from other households. The shares from all these sources are fixed in the benchmark level and thus relative shares do not change across experiments. Spendable income equation of household is specified as;

$$Y_h = [YF_h + \overline{RM_h} \cdot ER + \overline{DV_h} + \overline{GTR_h} + \overline{NHTR_h}] \cdot (1 - th_h - s_h) \tag{1.19}$$

where, $\overline{RM_h}$, $\overline{DV_h}$ and $\overline{GTR_h}$ are the shares of household income from remittances, dividends and government transfers respectively. $\overline{NHTR_h}$ is the net transfer of resources among households. This is calculated as $\overline{NHTR_h} = \overline{HTR_h} - \overline{HYP_h}$, where $\overline{HTR_h}$ and $\overline{HPY_h}$ are transfer receipts and transfer payments by the same household groups. Income tax rates and savings rates for different household groups are denoted by th_h and s_h respectively.

Government Income

Government derives income from all indirect and direct taxes and part of capital income to reflect the income generated from public sector corporations. The income equation has the form:

$$\begin{aligned} YG = & \sum_h th_h \cdot Y_h + \sum_i tm_i \cdot \overline{PWM_i} \cdot M_i \cdot ER + \sum_i st_i \cdot \overline{PWM_i} \cdot M_i \cdot ER \\ & + \sum_i td_i \cdot X_i \cdot PD_i + tc \cdot YC + YFG \end{aligned} \tag{1.20}$$

where, t_c denotes the corporate tax rate. YFG shows government income from capital. This is endogenously derived as $YFG = \zeta_f \cdot Y_f$. Where, ζ_f is a scalar showing government share of income from the capital factor only.

Corporation Income

Corporations generate all their income from capital only. There are no other sources of income for the corporate institutions in the model. Corporation income is represented by the following equation:

$$YC = \chi_f \cdot Y_f \tag{1.21}$$

where, χ_f is a scalar showing corporation share of income from the capital factor only.

Product Demand

Consumption Demand

Total consumption demand is composed of private and government consumption. Consumption behaviour of each household is specified in the form of a representative household (for each household group), maximising a Stone-Geary utility function subject to the budget constraint of the household:

$$U_h = \prod_i (CD_{ih} - \varphi_{ih})^{\beta_{ih}} \qquad (1.22)$$

Maximisation of utility function subject to the household income yields a linear expenditure system of the form:

$$CD_{ih} = \varphi_{ih} + (\beta_{ih} / P_i) \cdot (Y_h - \sum_i \varphi_{ih} \cdot P_i) \qquad (1.23)$$

where, CD_{ih} is consumption of good i by household group h, φ_{ih} denotes floor or committed consumption of good i by household h and β_{ih} depicts the marginal budget

share of good i by household h and $Y_h - \sum_i \varphi_{ih} \cdot P_i$ denotes supernumerary income of each household.

Government Demand

The government is assumed to keep the real level of expenditure on each commodity fixed. Hence, government demand for commodity i is:

$$\overline{GD_i} = \beta_i^g \cdot \overline{GTOT} \qquad (1.24)$$

where, $\overline{GTOT}$ is total fixed government expenditure. In the application model β_i^g is zero for all sector except services, for which $\beta_i^g = 1$.

Intermediate Demand

Since the shares among different intermediate inputs in a sector and the ratios of intermediate inputs to total outputs are fixed, one can write the demand for intermediate inputs as:

$$INT_i = \sum_j \tau_{ij} \cdot IN_j \qquad (1.25)$$

where, τ_{ij} are input-output coefficients and IN_j are sectoral intermediate inputs.

Investment Demand

Total investment is always equal to savings in equilibrium. Total investment is composed of fixed capital formation only (i.e. no inventory investments as stock change is not modelled due to the lack of data). Capital investment by sector of destination is given by:

$$PK_i \cdot DK_i = \xi_i \cdot I \qquad (1.26)$$

where, DK_i is capital investment by sector i, PK_i is the composite price of capital installed sector i and ξ_i is the proportion of total capital investment accounted for by sector i. Investment by sector of destinations is then translated into demand for capital goods by sector of origin (ID_i), using a capital composition matrix κ_{ij}:

$$ID_i = \sum_j \kappa_{ij} \cdot DK_j \tag{1.27}$$

Savings

Total savings is the sum of household, government, corporate and foreign savings. Households save a fixed proportion of their income. Following equation specify the savings behaviour of the households:

$$SH_h = s_h \cdot Y_h \tag{1.28}$$

The government savings is the difference between the endogenous government income and exogenous government expenditure and transfers to the household groups. The government savings is thus:

$$SG = YG - \sum_i \overline{GD_i} - \sum_h \overline{GTR_h} \tag{1.29}$$

Corporate savings is the difference between endogenous corporate income and corporate tax and dividend payment to household groups. The corporate savings is thus:

$$SC = YC - \sum_h \overline{DV_h} - tc \cdot YC \tag{1.30}$$

The last component of aggregate savings is the foreign savings. Foreign savings is the difference between the value of imports and the value of exports, at world prices. The dollar value of foreign savings is then converted into domestic currency value using the relevant exchange rate. The aggregate or total savings is thus:

$$S = \sum_h SH_h + SG + SC + SF \cdot ER \tag{1.31}$$

Equilibrium Conditions

Factor Market Equilibrium

The labour market is particularly simple and full employment of factors (i.e. labour and capital) is assumed. Thus, the factor market clearing requires that total factor demands equal exogenously fixed factor supplies and the equilibrating variables are the average factor prices (W_f).

$$\sum_i FD_{if} - FS_f = 0 \tag{1.32}$$

Product Market Equilibrium

$$Q_i = INT_i + \sum_h CD_{hi} + GD_i + ID_i \tag{1.33}$$

Equation (1.33) is the material balance equation for each sector, requiring that total composite supply (Q) is equal to the sum of composite demands.

Balance of Payments

We impose the balance of payment (BOP) equation to clear the foreign exchange market. The inflows are exogenous but imports and exports are determined endogenously in the model. Since nominal exchange rate is fixed in this model, foreign savings are allowed to vary to clear the foreign exchange market.

$$[\sum_i \overline{PWM_i} \cdot M_i] - [\sum_i PWE_i \cdot E_i + \sum_h \overline{RM_h} + SF] = 0 \tag{1.34}$$

Savings-Investment Balance

The final macro closure is achieved through the equality of endogenously determined aggregate savings and exogenously fixed total investment. Thus, this closure is "Savings driven", in which total investment is fixed and the saving components are endogenous:

$$I = S = \sum_h SH_h + SG + SC + SF \cdot ER \tag{1.35}$$

In the model only relative prices are determined. Thus it is necessary to normalise the price system. We make the nominal exchange rate the numeraire against which all relative prices will be determined. One can virtually normalise around any nominal magnitude because it has no effect on real variables. On the other hand, normalisation basically closes the system and allows one to solve the model for prices as a function of exogenous parameters and policy variables.

C I R D A P

The Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP) is a regional, inter-governmental, autonomous institution, established in July 1979 at the initiative of the countries of the Asia-Pacific Region and the Food and Agriculture Organization (FAO) of the United Nations with support from several other UN bodies and donors. Its member countries include Afghanistan, Bangladesh (Host State), India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand and Vietnam.

The main objectives of CIRDAP are to (i) assist national action; (ii) promote regional cooperation, and (iii) act as a servicing institution for its member countries for promotion of integrated rural development through research, action research, pilot project, training and information dissemination. Amelioration of rural poverty in the Asia-Pacific region has been the prime concern of CIRDAP. The Centre is committed to the WCARRD Follow-up Programmes. The programme priorities of CIRDAP are set under four areas of concern: (1) agrarian development; (2) institutional/ infrastructural development; (3) resource development including human resources; and (4) employment.

Operating through designated Contact Ministries and Link Institutions in member countries, CIRDAP promotes technical cooperation among nations of the region. It plays a supplementary and reinforcing role in supporting and furthering the effectiveness of integrated rural development programmes in the Asia-Pacific region.